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Investigations in the Bark of Trees

By PROF. THOMAS MEEHAN,
Germantown, Penna.

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Prof. Thomas Meehan, Consulting Botanist of the Department, was selected for the work of an "Examination of the Bark of Trees," on account of his well known ability in this special direction.

THOS. J. EDGE,
Secretary.

INVESTIGATIONS IN THE BARK OF TREES.

By Prof. Thomas Meehan, Germantown, Penna.

The nature of the bark of trees, and the office of bark in the economy of plant life, are questions of great importance to the practical man. Considering their importance it is remarkable that so little attention is given to the subject in standard works on agriculture and horticulture. Whenever the subject has been introduced at conventions or gatherings of intelligent cultivators, it has resulted in displaying complete ignorance, or in inviting the shafts of wits, or volleys of ridicule. The author of this essay well remembers an instance where a merely practical man, but well known as an observant, successful fruit grower, detailed his method of helping "hide-bound" trees by longitudinal slittings in the bark. His remarks were received with guffaws. One learned disputant contended that we might as well talk of curing the rheumatism by slitting the flesh in a man's leg, while another in mock gratefulness extended his thanks to the presentor of the idea, as it had taught him that the trouble with a neighbor's night-barking dog was that he was hide-bound, and he could now remedy it by slitting up his sides. On another occasion, when some successful German fruit grower of Central Pennsylvania had described among his methods an annual coat of white wash over the trunks and branches of his apple trees, the statement was derisively received. There was a great deal of talk about pores in the bark—pores essential to plant breathing, the stopping up of which by the lime wash must certainly lead to injury. It was contended that success which had certainly followed this fruit grower's efforts were due to other conditions. Success followed in spite of the white-washing, they insisted. Great as had been his success, it would have been greater without it. It was, in their estimation, worse than labor thrown away.

If we take up works on practical gardening we find learned discussions as to the wisdom of scraping off the old bark of trees.

Bark, it is said, is given to trees for the purpose of protecting them from the hot sun in summer, or cold winds in winter, and it needs all the bark it can get. And again it would be argued that rough bark was a sign of ill health; and, as in the case of a sick man that needed more clothing to keep him warm, the old bark formed additional protection. Even those who saw health and productiveness in trees with smooth green bark, it would be finally concluded, mistook the coincidence for a cause.

Taking up works of a scientific character—text books on botany, and similar productions—we find comparatively little in relation to the nature and offices of bark. For all that we are taught in this manner, we are left to the conclusion that there is little practical difference between the bark of one tree and the bark of another tree; and that the clefts and rifts we see in old branches or trunks are simply the result of the mechanical law of expansion. As the wood of the tree increases in diameter the barky band has to give way from the internal pressure. The cracks occur in the weakest places. This is not actually taught, but it is the inference. The careful observer, however, notes that each tree has its own distinct character of bark, which would not be the case under mechanical expansion. One brought into practical acquaintance with trees could distinguish one kind from another though blindfolded, simply by feeling the trunk with his hand.

It must be evident, therefore, that there must be some general law operating to produce the infinite variety of bark which trees present, and that the investigation of the whole subject is a promising field of practical usefulness.

One cannot understand the nature of bark without a knowledge of how wood is formed, as bark is simply an outgrowth from the wood-cell, and is indeed the residuum, as it were, from the new annual wood layer.

Everyone understands that a new layer of wood is annually placed over the layer of last year, so that we can tell the age of a tree by the number of these concentric circles. But it is not strictly true that the new layer is placed there. It is the living tissue of last year that furnishes the material and really constructs the layer that forms the additional woody circle.

It was at one time supposed that wood was formed out of a mucous layer known technically as cambium, and which is found between last year's layer of wood and bark early in the summer. But this is now known to be but a store of food provided by the leaves and which is to furnish the material out of which the new layer of wood is to be formed. Woody tissue is formed of innumerably small cells, each of which is an individual in itself. A tree is simply an aggregate of individuals, which have united together for mutual protection, just as the individuals of a country unite to form a govern-

ment. In these microscopic cells the whole future character of the tree is hidden. Whether a tree is to be an apple, a pear, a peach or an orange, is all decided when the cell is formed. It is one of the most wonderful of all wonderful things in the history of nature that. though we may examine the structure and character of a single cell by the aid of the most powerful microscope, there still lie hidden life-problems of the most astounding nature, that will probably never be solved for us. A single cell may eventually develop to an orange tree or to an oak, but the strongest microscope fails to give us any forewarning of the fact.

These cells, which form the mass of wood out of which the tree is built, have only a single year of life. In our American deciduous trees they are born at midsummer, reach their full growth before autumn, carry along the chain of life till next midsummer, when they bring forth their young, and then die. This process is repeated year after year. The dead cells form the annual layers of wood. A tree is in fact but a huge mausoleum containing hosts of skeletons of the dead past.

It is extremely interesting to watch this process of cell-making, and the formation of the annual layer of wood. It can be observed without the aid of a microscope. Any tree will probaly answer. The observations made by the author of this paper were made in various years, on the common garden cherry, the cottonwood, and the apple. Early in the spring, as every boy knows who has made a whistle pipe, a watery liquid appears between the bark and the wood, which is the commencement of the separating process. By June this thin liquid becomes thick and somewhat viscid, and then is in its cambium state. If now the bark be entirely stripped from the branch or trunk and the exposed wood shaded a little to prevent evaporation, it will soon assume a greenish tint. In a few days numerous fine points equalling the sands of the sea in numbers, may be detected proceeding from the old wood, penetrating the cambium layer, getting larger and larger until they meet each other. This is the beginning of the annual woody layer. This all comes from the cells on the outside of last year's layer of wood. Each divides and forms two cells. These again divide and go on dividing with great rapidity, continuing the work for about six weeks, when the process of wood making comes to an end. All the annual increase in girth of trees in this climate occurs within this brief period, say from about the middle of June to the first of August. The trees experimented on by the author were the cottonwood and the silver maple. The rapid growth of these species make them favorable for such observations. Trees about twenty years old are best for the purpose, as the daily increase in girth and its total cessation are easily noted.

Before the wood in these bark-pealed branches makes its final

effort at growth, we may note a marked change in its earlier characteristics. It is yellowish and spongy. Before the end of the growing period, we come to understand what has been going on. When the food prepared by the leaves as cambium is nearly exhausted, and the cells by continual reproduction have lost a part of their vital power, what would have been wood under more vigorous conditions, is simply bark. The postulate may be presented that fibre or bark cells are simply a degradation of wood cells. Both have precisely the same origin.

Sometimes, however, a cell objects to being degraded. It prefers to remain a wood cell. In this case it continues to reproduce itself as a distinct organization from the main trunk, making its own wood and bark annually as in its former history. Then we have the knots or burs, as these excrescences are popularly called, on the trunks of trees. They are very common in the weeping willow. In the cherry tree they are often so numerous and in old trees so large that one may almost use them as steps for climbing the tree. Figure 1 is an illustration of a cherry bur. It is a vertical section and shows the annual rings of wood, just as in the parent trunk. Eight or nine years before, when the bark cells were being formed out of the fibrous tissue, one cell remained attached to the main body as a wood cell. It then continued to make its own bark and circles of wood annually, just as the main stem was doing.

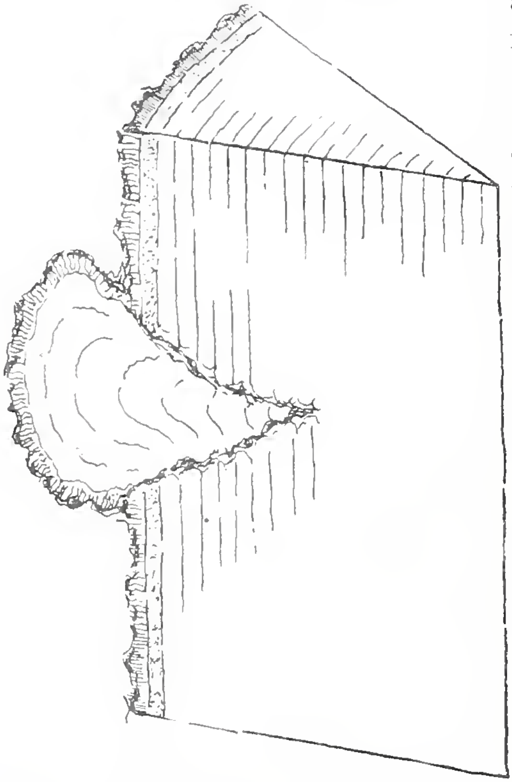

Fig. 1. Excrescence or bur on trunk of a cherry tree.

A careful study of this cut will enable us to understand, what often seems mysterious, the presence of bark within the wood of trees. The bark formed by bur or knob, as it increases in size annually, is covered by the annual deposit of wood in the main trunk though compressed considerably from the growth-pressure of the cells. In the wistaria, hornbeam, and especially in those sub-tropical leguminose plants known as bauhineas, bark is found abundantly within the wood of large stems. A careful examination of the annual deposits of wood will show that this has resulted from irregular growth of the wood cells. In some portions of the trunk a set of cells has ob-

tained more nutrition than others, and thus able to make more vigorous growth than neighbors to the right and to the left of them. There was nothing left to do but to spread to the right and to the left, just as the excrescence would do. overlapping the weaker growing wood and bark on each side.

In these cases, however, the production of an annual layer of bark still goes on, though compressed frequently into a very thin line, and this prevents the perfect consolidation of the wood such as is accomplished in grafting, in which process the growing cells in the scion and stalk unite before the bark cells are formed. This will explain some peculiar marks on the trunks of trees that often attract the attention of the curious. For instance in figure 2. which is a portion of a trunk of the canoe or paper birch, at A starts a rough line of dark black color which forms a V shaped hood over a large wound. b, now nearly covered by new wood and bark—nearly healed, as we say in forestry practice. Again there is another rough black line starting upwards at d and ending at c. For many years these peculiar marks on trees were a mystery to the author. They could not be explained by an exposition of the manner in which wood and bark was explained in the text books. When understood as explained in this paper, the manner of formation is clear: Some years back the tree had forked at d. As the branches forming each prong increased annually and came nearer together. the bark kept the woods of each from uniting, so that the fork appears to start some twelve inches above the point, and much further to the left, than it did in the first instance. This happens to be very clear in this case, but in many instances the explanation is not so apparent. In the inverted V shaped mark originating at a, for instance. All included within the V line is wood belonging to the branch that has since been cut away. The original starting point of the branch was on the line of a, but growing at an acute angle, and the growth of the stem covering the base of the side branch makes the difference. In brief, an inch of the lower portion of the side branch is imbedded in the wood of the main stem.

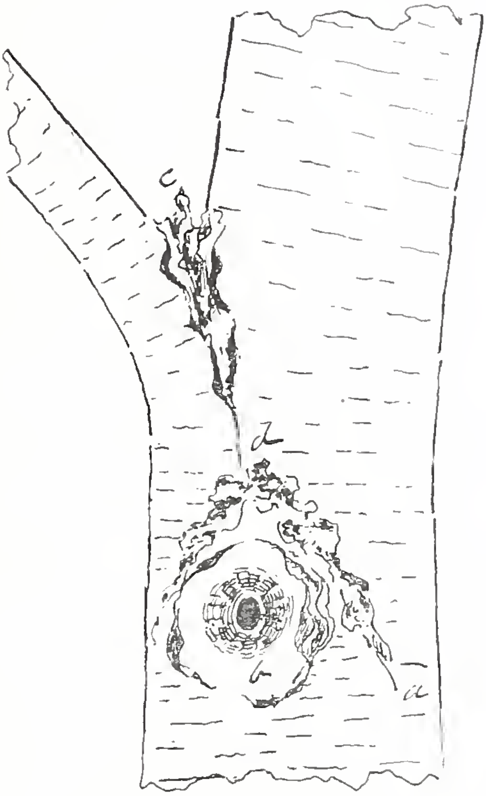

Fig. 2. Bark enclosed by the annual deposits of wood.

We now come to an examination of bark in its separate state of existence from wood. The outer layer of wood is the last formed of that division of the tree structure, while it is the inner layer of bark that is the one most recently constructed, the outer layer having been the inner bark of many years before.

A remarkable feature now strikes the careful observer. While there is reason to believe, as already noted, that wood cells have little more than a year of life, that in fact a tree trunk is little more than a mass of skeletons of what were once cells full of life and activity, the bark, though ushered into life under a low degree of vital power, seems to have an indefinite period of active existence. Every one knows the difference between live and dead bark. If in the spring we desire to know whether a tree transplanted in the fall has got through safely or not, we simply scratch the bark. If it is brown, the bark is dead—if green and sappy, we know it is full of life.

So with trees of various ages. The outer bark is not dead as long as we find it will stand the above test. As a general rule the external coating is alive as long as it is known as smooth bark. When it reaches the condition of rough bark, the outer coating consists of dead material.

The age at which trees take on the rough bark varies with the species. In the common sweet chestnut *Castanea Americana*, the bark continues to retain life, and thus preserve its smooth condition until it is about 25 years old. The European form, *Castanea Vesca*, probably retains for about the same time, the same conditions, but the exact period has not been closely calculated. Most of the oaks begin to show the presence of rough bark at about ten or eleven years, and the apple about the same. The sassafras has rough bark two or three years after its first formation. Some poplars start to exhibit rough bark very early in life, as for instance the abele or silver poplar; the gray poplar presents this condition later, while the class known as aspens do not have rough bark until very late in life. Some, as the beech, for instance, seem never to have rough bark, but in these cases it is not from the bark having had a long lease of life, but because of the casting off of the epiderm very early in life. The bark of the beech tree, full of life as it would seem, presents a thinner layer in old trees than almost any other tree. It seems a mere papery shell.

When we take for examination a twenty year old trunk of a sweet chestnut tree of perhaps nearly a foot in diameter, and note that the outer bark is actually the same layer that encircled the branch when it was but an inch thick, we may wonder why the bark did not crack by the pressure of wood-growth from the interior. This thought occurs to us in connection with all trees. Indeed, some text books have taught that the bark of trees is disrupted mechanically by the

pressure of wood-growth from the inside. The example furnished by the chestnut shows that this is not the case. As long as there is life there is elasticity in the tissue, and it becomes in a measure netted--veined.

By reason of this the annual layers of the chestnut tree are thinner on the outside than those in the interior next to the wood. Only for this arrangement the bark of a twenty year old chestnut tree would be of enormous thickness. In some trees the netted character of the bark, after expansion as stated, presents a pretty piece of nature's handiwork. The linden, especially, is beautiful in this respect. In the West Indies there is a species that behaves so prettily in this respect that it is known as the lace-bark tree. Botanically it is *Lagetta lintearia*. One of our own native shrubs, *Dirca palustris* or leatherwood, presents us with a bark of a similarly woven character, though on a minor scale. Figure 3 represents the expanded bark of the West Indian lace-bark tree.

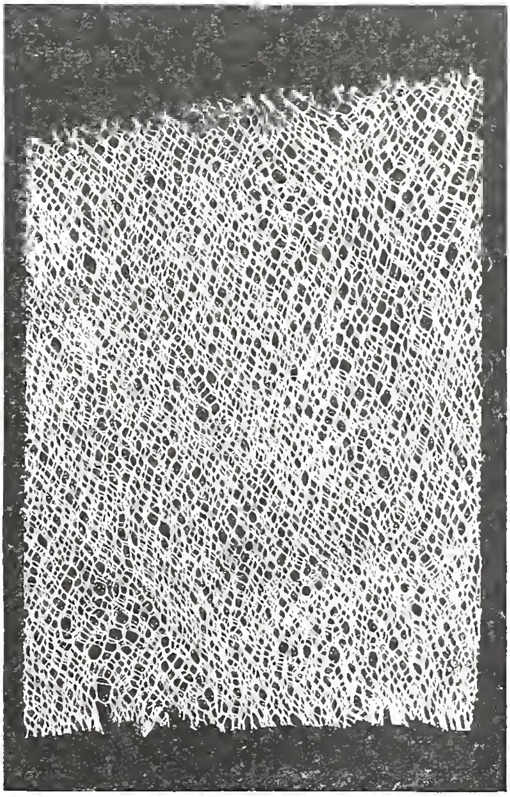

Fig. 3. One of twelve annual layers of bark from twelve year old branch of the Lace-bark tree-*Lagetta lintearia*.

If, then, there be no cracking or rifting of the bark while it has a hold on life, how does the rough bark originate?

The first striking thought, on examining different kinds of trees, is that no trees have exactly the same character of rough bark, any more than have the rough bark appear at the same time of life. But each tree of any one species has precisely the same bark characters. One accustomed to noting the peculiarities of trees can determine the species almost as well by feeling the trunks in the dark, as by examining the leaves or fruit in the day time. The swamp white oak, for instance, *Quercus bicolor*, has a somewhat scaly bark. So has the white oak, but the scales of the white oak are in longish strips and comparatively thick, while those of the swamp white oak are thinner and rounder. The mossy cup oak has deep fissures, but the ridges are soft and yet roughish; while the common chestnut oak, *Quercus montana*, has deep fissures, but the ridges are broad, hard

and with a smooth surface. The old bark of the black oak, *Quercus tinctoria*, is broken into numerous small ridges, and these ridges usually separated by transverse divisions,—while the bark of the red oak continues smooth and riftless to a late period of life. It is also late in life before the royal oak, *Quercus Robur*, assumes the rough-bark condition. Other trees, such as the beech and cherry, form rifts horizontally, and the bark is thrown off in sheets running round the branch. Then there is a class, such as the planes or buttonwoods, and various species of thorns and the apple tree, as in Fig. 4, which forms its rough bark in scales or plates, which it is continually throwing off, apparently with no regular rule as to time or manner. Still others are covered wholly or in part by corky layers, giving the tree a rough and jagged appearance in connection with its bark arrangements. In this we find the cork oak; the sugar berry or celtis; the wahoo, and other elms; and more or less in many trees. All these peculiarities could not be so remarkably individualized if the rough bark of trees resulted from mere mechanical law of internal pressure. The rifts would be irregular, and the faster growing branch would have a different character of rifts than would the weaker one growing on the same tree. There must be a definite law operating in each species of tree, to produce this specific uniformity in each case.

It would appear that nature has little use for bark after it has performed the work that was given it to do, the chief of which must be the protection of the moist cambium layer during its early liquid state. Only for this protection it would evaporate faster than it could be formed. This is evident by watching the results of stripping off the entire bark in early midsummer, as already referred to, when the old mother cells send the daughter cells into the prepared cambium liquid, and in a few days form an absolutely new layer of wood and bark over the whole wound. Shade has to be provided to insure the success of this effort of nature. If exposed to hot sun or dry winds the new wood and bark is successfully formed only in patches. We learn from this that protection of the cambium layer is the chief office of the outer bark. In some works it has been taught that the office of the rough bark is protection from cold, and that it must be an injury to remove it. But when we understand that the chestnut and other trees cited will retain their smooth bark for ten or twenty years, and these smooth-barken branches get through severe winters as easily as those clothed with the rough bark, it requires no argument to prove that this reasoning is very far fetched.

The fact is, nature provides, from the earliest formation of the bark, machinery for the destruction of the bark when it is no longer of any service. This provision is in creating cork cells, which, when the proper time comes, develop in various directions, each species of tree bearing its own character of cork-cell growth, and thus giving the

peculiar individualized character of rough bark already noted. These cells are sometimes referred to in elementary works as suber cells. In some cases they are termed lenticels. In the earlier stages of the growth of branches these lenticels give the bark a freckled appearance, and it is from this that the term lenticel is derived. Their true nature, until the publication of this paper, has not been reported. All that has been said of them is that they are mere vent holes by which the plant can exchange a little exhausted air for a new and fresh supply. It is only during recent years that it has been noted that cork is one of nature's destructive agents. The fall of the leaf is due to the production of cork cells at the disarticulating point; and whole branchlets, as in the oak and arbor vitae, are separated and thrown off by the same mighty power. These cells, as already noted, are formed at the earliest period of stem structure; but they do not journey on their destructive errand until nature desires to remove some part that is no longer of any service. It is because they do not develop in the chestnut branch in its earliest stages that the bark continues smooth. When they do start to grow, they progress in different directions, usually taking a course in line with the direction of the branch. This is particularly evident in those oaks which have deep rifts in the rough bark. When these cells start their rapid development they meet each other eventually, and the rift is complete. After that the mechanical law comes into play, and the rifts get wider by the interior pressure as the trunk increases in girth. In some trees, however, the cells develop transversely. When they meet each other, the bark then peels off in sheets around the trunk. This is seen in the birch in Fig. 2. In that comparatively young specimen though the early lenticels have developed to straight lines, they have not yet reached each other, and the paper-white layer is still intact. In Fig. 4, which represents a middle aged cherry tree the lines have reached others, and have had sufficient lateral influence to deaden the cuticle, which then cracks vertically by the mechanical

Fig. 4. A Cherry tree with peeling bark.

pressure from the interior, and the bark is peeling off in irregular flakes. In the sycamore or buttonwood the cork cells develop beneath the outer cuticle, radiating in every direction, though with variable energy, and in this way the destruction results in irregular plates of dead bark. This is the manner in which also the cork cells are developed in the apple tree, as illustrated in Fig. 5, representing a large branch of an apple tree. The development is so irregular in this case that portions of the bark are thrown off in different years. The lighter patches are when the bark of last year was thrown off. The cracked and more rugged portions of the surface will be thrown off before the close of the present season, and next year will appear as the lighter patches do now. On the surface of the lighter spots are small protuberances. These are miniature woody excrescences as described in Fig. 1, but they are so weak that they do not increase faster than the normal wood and bark grows. They may in time become wholly imbedded in the regular woody tissue, and then we have the peculiar formation of wood which is so familiar to us as "bird's eye maple." Figure 6 shows the manner in which nature gets rid of the bark in the pear tree. I my studies in the formation and place in nature of bark, I have often been struck by the similar behavior of cork cells, and of some destructive fungi, when in a condition of active development. I am often led to believe there is a closer relation between them than is generally suspected. This suggestion is particularly prominent when we consider the decortication of the pear. Here, as in the apple, the cork cells develop beneath the surface and at irregular seasons, but the destructive agency extends almost to the last year's layer of the inner bark, and does not separate it from the inner layer as happens in the apple. Being killed, however, it separates from the still living portions on the boundaries by shrinkage, leaving a

Fig. 5. An apple branch of moderate age.

deep and very narrow chasm surrounding its field of operations. The dead portion curls up in drying, and thus is forced off eventually by purely mechanical law. This is so exactly like the operations of some parasitic fungi that only for the fact that we may naturally look for some extreme of the method adopted in the apple, that we conclude to have found this extreme in the apple's closely related species, the pear. I am the more inclined to believe that we are here on the borders of fungi land, from the fact that washing the trunks of pear trees with whale oil soap evidently retards the development of the cork cells, just as it does in the development of parasitic fungi.

Fig. 6. Main stem of a 12 year old Pear tree.

It has been noted how, in some cases, bark seems to retain an extended lease of life, as in the case of the chestnut bark, and that in such cases the bark acts in some manner as leaves would in the general good economy of the plant. In some cases, indeed, plants have not other leaves than such as appear as bark, surrounding the woody tissue of the stem structure. The cactus family is an illustration. The plant consists wholly of bark and woody stem. A new layer is formed every year in the cactus plant, just as in other plants,—a new layer of wood in the exterior and of bark on the interior of the old layers respectively. When the cactus plant dies, and the bark is removed, this is evident. Not a particle of bark tissue is attached to the wood. There are no leaves, except the minute apices of leaves in a very early stage in a few instances. The whole leaf structure, which theoretically we associate with plants in general, has been retained as bark, the life of which is of the most enduring character. This longevity is due to the utter absence of lenticels in the structure of the cactus bark. It was not the purpose of nature to introduce these death-providing elements here. It was the purpose to provide a succulent coating for the wood, and an epiderm that should be able to resist transpiration. Cork cells here, with their destructive powers, would defeat the object, hence they are wisely wanting.

The union of leaves so as to form a succulent coating of bark, as we see it in cactuses, is a power not confined to cactuses, and other plants only, but occurs in parts of plants usually devoid of succulence. It is very common in the form of fleshy fruits, notably the apple and the pear. In many of these instances the transformation from bark in its normal condition to that of the succulent clothing of the fruit has been so imperfectly formed that the lenticels are still present, though their powers of development have become abridged. Nature has little use for them here, trusting to genuine forms of microscopic fungi to perform the duty of inducing decay. Still, where the lenticels are present, even in a somewhat obscure condition, use is made of them. This is evidenced in the apple. Some of these are known as russets, from the brown, rough condition of the surface. This is wholly the work of minute cork cells, which have developed to such an extent as wholly to destroy the epiderm or outer cuticle. In many kinds of apples these latent cork cells can be seen as very white specks on the apple skin. In most cases they continue dormant to the end. In the case of the russets they start to extend very early and the whole cuticle is destroyed by the time the apple is full grown. The scurfiness of a russet is due to the fine, dead skin by which it is covered and which was destroyed by the growth of the corky element. It is very interesting to watch this process in the growing apple of a russet variety. It is at first green, the lenticels seem to open, and the tiny brown spots soon meet each other and cover the whole surface of the skin.

Fig. 7. Bartlett pear, half size, the dark lines marking the regular progress of the russetting over the yellow skin.

Like all things in nature, where nothing seems exempt from variation resulting from different degrees of life-energy, the development of cork cells on the rind of the apple and pear varies in intensity. In some cases they develope partially only. Then we have simply a little russet on one side of the pear or at the base of an apple. Occasionally there is exhibited a sudden spurt of extra energy, when we have a russet appear on fruits or parts of fruits in an apparently indiscriminate manner. An apple will appear with its lower half

russet, with the upper of the normal green. The author of this paper has seen an apple in which one-fifth of its longitudinal section was russet, the other four sections of the regular green tints. Fig. 7 represents a Bartlett pear which early in the season undertook the development of its cork cells, and clothed itself with russet, and by September had reached the stage illustrated here. The development and gradual extension of the cork cells, destroying the cuticle, and producing the russety surface, could be readily traced by the aid of an ordinary pocket lens. It furnishes one of the most instructive lessons in morphology, that the fleshy coating of the apple or pear is of the nature of a branch with its usual quota of cork cells in its outer bark, which when the proper order of business in the life of a plant is reached, becomes the agent of destructiveness to parts no longer needed. And the development in what seems to be unusual cases is again only what is an experience of every day life that in the most orderly assemblages there will be now and then instances of disorder.

Although I offer these results of my personal investigations as an original contribution to biological science, I have not forgotten that they are to be read chiefly by the practical agriculturist, to whom the use of unfamiliar scientific terms would render the points unintelligible. While this will make the treatise less acceptable to the student, to whom the language of science means a clear perception of the writer's thought, the paper may be more directly useful.

The main idea has been to show the tree grower that old bark is of no value to a tree—that nature herself has provided means wherewith to get rid of it when no longer useful,—and that the practical man may render himself good service by trying to aid nature in getting rid of a useless article.

Washes for the bark of trees will, therefore, in many instances, be eminently useful.